A Prospective Study of Diet Quality and Mortality in Women

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Context Most studies of diet and health care have focused on the role of single nutrients, foods, or food groups in disease prevention or promotion. Few studies have addressed the health effects of dietary patterns, which include complex mixtures of foods containing multiple nutrients and nonnutrients.

Objective To examine the association of mortality with a multifactorial diet quality index.

Design and Setting Data from phase 2 (1987-1989) of a prospective cohort study of breast cancer screening, the Breast Cancer Detection Demonstration Project, with a median follow-up of 5.6 years.

Participants A total of 42 254 women (mean age, 61.1 years) who completed the food frequency questionnaire portion of the survey.

Main Outcome Measure All-cause mortality by quartile of Recommended Food Score (RFS; the sum of the number of foods recommended by current dietary guidelines [fruits, vegetables, whole grains, low-fat dairy, and lean meats and poultry] that were reported on the questionnaire to be consumed at least once a week, for a maximum score of 23).

Results There were 2065 deaths due to all causes in the cohort. The RFS was inversely associated with all-cause mortality. Compared with those in the lowest quartile, subjects in the upper quartiles of the RFS had relative risks for all-cause mortality of 0.82 (95% confidence interval [CI], 0.73-0.92) for quartile 2, 0.71 (95% CI, 0.62-0.81) for quartile 3, and 0.69 (95% CI, 0.61-0.78) for quartile 4 adjusted for education, ethnicity, age, body mass index, smoking status, alcohol use, level of physical activity, menopausal hormone use, and history of disease (χ^2_1 for trend=35.64, $P<.001$ for trend).

Conclusions These data suggest that a dietary pattern characterized by consumption of foods recommended in current dietary guidelines is associated with decreased risk of mortality in women.

JAMA. 2000;283:2109-2115 www.jama.com

Although many studies have examined the role of single nutrients, foods, or food groups in the etiology of disease,[1-3] relatively little research has addressed the health effects of dietary patterns comprising multiple interdependent dietary factors.[4] Research on dietary patterns is warranted on several grounds. First, complex diets consumed by free-living individuals do not consist of single nutrients or foods but rather a combination of foods containing multiple nutrients and nonnutrients. Second, intercorrelation of dietary variables makes it difficult to isolate effects of single nutrients or foods. Third, in vivo biological activities of nutrients are interdependent.[5-7] Finally, recommendations for disease prevention implicitly reflect the dietary-pattern approach by emphasizing the simultaneous change of several dietary behaviors, such as increasing fruit, vegetable, and grain intake, and decreasing fat intake.[1,3]

This study examines prospectively in a large cohort of women the relationship of all-cause and cause-specific mortality with a measure of overall diet quality derived from current food-based dietary guidelines.

METHODS

For this study, we used data from the Breast Cancer Detection and Demonstration Project (BCDDP), sponsored by the National Cancer Institute and the American Cancer Society. Between 1973 and 1979, the project screened 283 222 women aged 35 through 74 years in 29 screening centers in 27 cities throughout the United States.[8]

See also Patient Page.

Follow-up Study of the BCDDP Cohort

In 1979, the National Cancer Institute began a follow-up study of a subset of the BCDDP participants (phase 1, 1979-1986).[8] The subset of 64 182 women included (1) all women with pathologically confirmed incident breast cancers identified during the screening phase (n=4275), (2) all women with biopsy-proven benign breast disease identified during the screening phase (n=25 114), (3) all women who had an

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identified abnormality on 1 or more of the screening examinations but did not have a biopsy (n=9628), and (4) a sample of healthy women who had no abnormality or recommendation for a biopsy during the screening phase and matched women in groups 1 and 2 for several criteria (n=25165). The age distribution and the education level of the follow-up cohort were comparable with those of all BCDDP participants. The data were collected using a baseline telephone interview and up to 6 annual telephone interviews until 1986.

For phase 2 follow-up (1987-1989), a questionnaire was mailed to all surviving members of the follow-up cohort; 51694 women responded. A 62-item food frequency questionnaire was used to collect dietary information during this phase. A modification of the instrument was developed by Block and coworkers.[9-11] This food frequency questionnaire has been validated among older women and includes queries about frequency of consumption and the size of portions consumed over the past year. Another questionnaire was mailed to all follow-up cohort members in 1993 through 1995 (phase 3). Other information collected at phases 2 and 3 included history of exogenous hormone use, medical history, information on end points other than breast cancer, tobacco and alcohol use, use of vitamins, physical activity, and updated family and reproductive history.

During each follow-up phase, women who did not respond to the mailed questionnaire were interviewed by telephone, if possible. Extensive efforts were made to contact women not located at phase 3, including tracing them through the National Death Index of the National Center for Health Statistics through December 1993.

Analytic Cohort

For the purpose of analyses reported herein, phase 2 (1987-1989) was considered the baseline. Of the 51694 women who returned mailed food frequency questionnaires, 9437 (18.3%) were excluded because the responses were either grossly incomplete (missing information on >10 questions) or deemed unreliable based on previous validation studies.[9,10] Three questionnaires completed by proxies were also excluded, leaving 42254 women in the analytic file. In this cohort of 42254 women, 2065 deaths due to all causes occurred between phase 2 (1987-1989) and phase 3 (1993-1995). This included 223 deaths (10.8%) for which a death certificate was not available but death was confirmed by other sources. The cause-of-death information was coded as listed on the death certificate. The characteristics (age, ethnicity, body mass index [BMI], and level of education) of subjects in the analytic cohort were comparable with those of the women who responded to the phase 2 questionnaire.

Measure of Diet Quality

Using the 62-item questionnaire from phase 2, we developed a Recommended Foods Score (RFS) to measure overall diet quality. The RFS is based on reported consumption of foods recommended by current dietary guidelines.[1-3] The RFS is similar to the dietary variety score for recommended foods that we had developed for use with the National Health Interview Survey data.[12] Briefly, because current dietary guidelines emphasize consumption of fruits, vegetables, whole grains, lean meats or meat alternates, and low-fat dairy, we decided that all questionnaire items corresponding to these groups would contribute to the score. Furthermore, because of measurement error associated with amounts reportedly consumed, we designed the diet quality measure to be independent of reported amounts.[13,14] We used the following 23 food frequency questionnaire items for the RFS : apples or pears; oranges; cantaloupe; orange or grapefruit juice; grapefruit; other fruit juices; dried beans; tomatoes; broccoli; spinach; mustard, turnip, or collard greens; carrots or mixed vegetables with carrots; green salad; sweet potatoes, yams; other potatoes; baked or stewed chicken or turkey; baked or broiled fish; dark breads like whole wheat, rye, or pumpernickel; cornbread, tortillas, and grits; high-fiber cereals, such as bran, granola, or shredded wheat; cooked cereals; 2% milk and beverages with 2% milk; and 1% or skim milk. The RFS is calculated by the sum of the 23 items that subjects mentioned they consumed at least once a week, for a maximum score of 23. The remaining 39 items on the food frequency questionnaire did not meet the criteria for inclusion in the RFS.

Statistical Analyses

The number of person-years contributed by a subject was calculated from the date of phase 2 follow-up interview to the date of death (n=2065) or the date last known alive (n=40189), whichever came first. The date last known alive was the date of the phase 3 interview for those who answered the questionnaire (n=36188), date of last telephone contact for nonrespondents to the phase 3 mailed questionnaire (n=1872), and date of last National Death Index search (December 31, 1993) for nonrespondents to both mail and telephone contacts at phase 3 (n=2129). We used Cox proportional hazards regression to examine the independent association of the diet quality measure with mortality in the presence of covariates with follow-up time as the underlying time metric.[15] The analyses were done using the PROC PHREG procedure in the SAS software package.[16] We categorized the RFS into approximate quartiles based on its distribution in the analytic cohort. The risk of mortality in each of the upper 3 quartiles was compared with the risk for the lowest RFS quartile. To evaluate the linear trend with mortality, we entered RFS in regression models both as a continuous variable and a scored variable ranging from 0 to 3. The trend results were essentially unchanged when the RFS was scored as the median value in each quartile. The proportional hazards assumption required by the Cox regression model was found to be acceptable for the primary multivariate analysis involving quartiles of RFS (χ^2_2, 1.71; P=.42).

The covariates in the regression model were chosen a priori based on potential correlates of health outcome and included the following baseline variables: age; race; educational level; BMI; smoking status; alcohol intake; energy intake; history of cancer, heart disease or diabetes; menopausal hormone use status; and a physical activity measure (whether a participant engaged in regular physical exercise long enough to work up a sweat at least once a week). Results were similar when we examined other forms of covariates, including a quantitative alcohol intake variable, smoking duration and number of cigarettes smoked per day, as well as a quantitative physical activity variable reflecting hours spent at different activity levels. Inclusion of a weight change variable (ie, screening weight minus weight at phase 2) did not affect the results shown.

To test for statistical interaction between the RFS and various covariates, we entered into the regression models interaction terms reflecting the product of RFS and each of the listed covariates.

RESULTS

The median follow-up time was 5.6 years. The mean (SE) of the RFS in the analytic cohort was 11.4 (0.02). The mean age of the analytic cohort at baseline (phase 2 interview) was 61.1 (range, 40-93) years. TABLE 1 presents the distribution of risk factors of mortality by quartiles of RFS. More than 87% of the analytic cohort was white and had 12 or more years of education. Generally, subjects with higher RFS were slightly older; more educated, physically active, likely to drink alcohol, and use supplements regularly; less likely to be smoking currently.

Table 1. Distribution of Risk Factors of Mortality by Quartiles of Recommended Foods Score in 42 254 Women in the Breast Cancer Detection and Demonstration Project Cohort*

	Recommended Foods Score, Median (Range)			
	Quartile 1 7.0 (0-8) (n = 8890)	Quartile 2 10.0 (9-11) (n = 12 070)	Quartile 3 12.0 (12-13) (n = 9088)	Quartile 4 15.0 (14-23) (n = 12 206)
Recommended food score, mean (SE)	6.4 (0.02)	10.0 (0.01)	12.5 (0.01)	16.0 (0.07)
Age, mean (SE), y	60.4 (0.09)	60.8 (0.07)	61.3 (0.08)	61.8 (0.07)
Body mass index, mean (SE), kg/m^2	25.3 (0.05)	25.0 (0.04)	25.1 (0.05)	24.9 (0.04)
Follow-up time, mean (SE), y	5.5 (0.01)	5.5 (0.01)	5.5 (0.01)	5.5 (0.01)
White	85.6	87.4	88.8	87.2
≥12 y of education	84.0	88.3	90.3	91.5
Regular supplement user	44.4	51.1	56.4	59.4
Current smoker	19.7	13.1	9.8	8.2
Drink alcoholic beverages	45.9	49.5	52.3	53.4
Physical activity (≥1 time per week)	38.6	50.5	56.4	64.2
History of cancer	14.2	14.9	14.7	14.9
History of heart disease or diabetes	12.4	13.3	12.9	13.0
Current menopausal hormone user	17.1	18.9	18.9	19.8

*Recommended Foods Score is defined as sum of foods recommended in current dietary guidelines mentioned at least once per week in the food frequency questionnaire, with a maximum score of 23. All data are presented as percentage unless otherwise indicated.

Table 2. Daily Mean (SE) Intake of Energy and Selected Nutrients by Quartiles of Recommended Foods Score in 42 254 Women in the Breast Cancer Detection and Demonstration Project Cohort*

	Recommended Foods Score, Median (Range)				
	Quartile 1 7.0 (0-8) (n = 8890)	Quartile 2 10.0 (9-11) (n = 12 070)	Quartile 3 12.0 (12-13) (n = 9088)	Quartile 4 15.0 (14-23) (n = 12 206)	Pearson Correlation Coefficient†
Energy, kcal‡	1089 (5)	1218 (9)	1291 (6)	1433 (5)	0.24
Protein, g	45 (0.2)	53 (0.2)	58 (0.2)	66 (0.2)	0.33
Fat, g	48 (0.3)	50 (0.2)	50 (0.3)	52 (0.2)	0.07
Percentage of energy from fat	39 (0.1)	36 (0.1)	34 (0.1)	32 (0.1)	−0.29
Percentage of energy from carbohydrate	43 (0.1)	45 (0.1)	47 (0.1)	49 (0.1)	0.26
Dietary fiber, g	7 (0.04)	10 (0.05)	12 (0.06)	15 (0.07)	0.45
Vitamin C	80 (0.8)	122 (1.4)	146 (1.3)	182 (1.4)	0.28
Vitamin E, mg§	6.6 (0.07)	7.8 (0.06)	8.7 (0.07)	9.9 (0.18)	0.11
Folate, µg	186 (1)	245 (2)	283 (2)	334 (3)	0.22
Provitamin A carotenoids, µg	1688 (17)	2571 (18)	3273 (25)	4282 (25)	0.42

*For definition of Recommended Foods Score see Table 1. All data are presented as mean (SE).
†Correlation of Recommended Foods Score with energy and nutrient listed in Table. All correlations were significant ($P<.05$).
‡Includes energy and nutrients from all foods reported; excludes vitamin or mineral supplements. To convert to joules multiply by 4.2.
§Measured by tocopherol equivalents.

TABLE 2 presents the mean (SE) of intake of energy and selected nutrients by quartiles of RFS. Correlation of RFS with intake of energy and selected micronutrients is also presented. Generally, the RFS was positively associated with intake of energy and protein, percentage of energy from carbohydrate, and micronutrient intake but inversely associated with percentage of energy from fat.

TABLE 3 presents the age-adjusted and multiple covariate–adjusted estimates of risk of all-cause mortality. The multiple covariate–adjusted relative risk estimates associated with the upper 3 quartiles of RFS in reference to the bottom quartile were 0.82 (95% confidence interval [CI], 0.73-0.92) for quartile 2, 0.71 (95% CI, 0.62-0.81) for quartile 3, and 0.69 (95% CI, 0.61-0.78) for quartile 4, (χ^2_1 for trend=35.64; $P<.001$). We also ran these analyses with approximate decile cuts of RFS and observed a similar trend (β, −.04 [SE, .008]; χ^2_1 for decile trend=30.64; $P<.001$). The results shown in Table 3 were unaffected by exclusion of 223 deaths not confirmed by death certificates.

To test for a nonlinear trend, a 3-knot cubic regression spline,[17] which involves 2 continuous variables, the linear RFS variable and a nonlinear cubic expression of the RFS variable, was fit to the data. A statistically significant nonlinear trend was noted (β associated with the nonlinear variable was .00030 [.00012]; χ^2_1=6.09; P=.01). Relative to analyses with only a linear trend, the shape of the nonlinear trend showed a sharper decline in risk of mortality for RFS values ranging from 0 to about 11 with a leveling off for RFS values greater than 11. This observation is consistent with the pattern of risk reduction associated with quartiles of RFS in multiple covariate–adjusted regression models in Table 3. The greatest decrease in risk of mortality was present going from the first to the second quartile with leveling off between quartiles 3 and 4, for which the RFS values are in the 12 and greater range.

To exclude the possibility that subjects with clinical disease may differ in dietary patterns at baseline, we examined the RFS-mortality association after exclusion of those reporting history of cancer, diabetes, or heart disease at baseline (1193 deaths). Similarly, to exclude the possibility of those reporting poor diets at baseline due to preclinical disease, we reexamined the RFS-mortality association after excluding the first 2 and 3 years of follow-up. The inverse RFS-mortality association persisted ($P<.001$) after these exclusions (TABLE 4).

In our analyses of potential interaction between the RFS and several covariates (education, smoking status, physical activity, alcohol intake, BMI, menopausal hormone use status, and energy intake) in altering the RFS-mortality association, none of the interaction terms was significant (data not shown).

TABLE 5 shows the relationship between RFS and mortality from all-sites cancer, coronary heart disease, stroke, and all other causes combined. An inverse association of RFS with mortality from each cause was noted. For all-sites cancer, coronary heart disease, and stroke mortality, respondents in the highest quartile of RFS had at least 30% lower risk than those in the bottom quartile.

COMMENT

Our study suggests that women reporting dietary patterns that included fruits, vegetables, whole grains, low-fat dairy, and lean meats, as recommended by current dietary guidelines, have a lower risk of mortality. Women in the highest intake level of recommended foods had 30% lower risk of multivariate-adjusted all-cause mortality compared with those in the lowest level. Our results provide evidence in support of the prevailing food-based dietary guidelines and suggest that diets complying with current dietary recommendations are indeed associated with improved health outcome. The potential public health implications of these findings are con-

Table 3. Age-Adjusted and Multiple Covariate–Adjusted Relative Risk (RR) Estimates for All-Cause Mortality by Quartiles of Recommended Foods Score*

	Recommended Foods Scores Quartiles, Median (Range)				For Trend	
Variables	Quartile 1 7.0 (0-8)	Quartile 2 10.0 (9-11)	Quartile 3 12.0 (12-13)	Quartile 4 15.0 (14-23)	χ^2_1	P Value
Full Analytic Cohort†						
No. of deaths	559	621	389	496		
Age-adjusted RR (95% CI)	1.00	0.79 (0.70-0.88)	0.63 (0.55-0.72)	0.56 (0.51-0.65)	87.55	<.001
Multivariate-adjusted RR (95% CI)	1.00	0.82 (0.73-0.92)	0.71 (0.62-0.81)	0.69 (0.61-0.78)	35.64	<.001
Excludes Those With Missing Covariate Information‡						
No. of deaths	432	452	298	367		
Age-adjusted RR (95% CI)§	1.00	0.74 (0.65-0.85)	0.62 (0.54-0.72)	0.54 (0.47-0.63)	75.48	<.001
Multivariate-adjusted RR (95% CI)§	1.00	0.77 (0.67-0.88)	0.71 (0.61-0.82)	0.66 (0.57-0.76)	30.01	<.001

*For a definition of Recommended Food Scores, see Table 1. Covariate adjusted regression models included: age; education level; race; smoking status; alcohol intake; body mass index at phase 2 by quartiles; energy intake in kilocalories; history of cancer, heart disease, or diabetes; postmenopausal hormone use status; active enough to sweat at least 1 time per week. CI indicates confidence interval.
†Includes all 42 254 subjects without exclusion. In all there were 2065 deaths in this group.
‡Consists of 33 259 subjects after excluding those with missing covariate information. In all there were 1549 deaths among this group.
§For this model, women with unknown information on any covariate were excluded.

siderable; despite increased public awareness of the importance of diet in decreasing the risk of chronic disease, large gaps remain in food-based recommendations and actual dietary practices of the US population.[18]

Few studies have examined global measures of diet quality as it relates to mortality. Nube et al[19] reported a significant positive association between 25-year survival and consuming a "prudent" diet, based on consumption of 10 food items, in men but not in women. In the first National Health and Nutrition Examination Survey (NHANES) Epidemiologic Follow-up Study, we found diets characterized by a low diet diversity score based on evaluation of whether each of the major food groups (fruit, vegetable, grain, meat, and dairy) were reported to be associated with an increased risk of all-cause mortality in both men and women.[20,21] Women consuming 2 or fewer food groups daily

Table 4. Relative Risk (RR) Estimates for All-Cause Mortality After Exclusion of Those With History of Disease at Baseline and After Exclusion of First 2 and 3 Years of Follow-up*

	Recommended Foods Score, Median (Range)				For Trend	
Variables	Quartile 1 7.0 (0-8)	Quartile 2 10.0 (9-11)	Quartile 3 12.0 (12-13)	Quartile 4 15.0 (14-23)	χ^2_1	*P* Value
		Excludes Those With Baseline Disease History†				
No. of deaths	251	247	162	212		
Age-adjusted RR (95% CI)	1.00	0.71 (0.59-0.85)	0.58 (0.48-0.71)	0.55 (0.45-0.66)	43.46	<.001
Multivariate-adjusted RR (95% CI)	1.00	0.78 (0.65-0.93)	0.69 (0.57-0.85)	0.68 (0.56-0.82)	15.86	<.001
		Excludes First 2 Years of Follow-up‡				
No. of deaths	411	464	283	393		
Age-adjusted RR (95% CI)	1.00	0.80 (0.70-0.91)	0.62 (0.54-0.73)	0.62 (0.54-0.71)	52.85	<.001
Multivariate-adjusted RR (95% CI)	1.00	0.84 (0.73-0.96)	0.70 (0.60-0.82)	0.73 (0.63-0.85)	20.08	<.001
		Excludes First 3 Years of Follow-up§				
No. of deaths	321	358	216	301		
Age-adjusted RR (95% CI)	1.00	0.79 (0.68-0.92)	0.61 (0.51-0.72)	0.60 (0.52-0.71)	44.64	<.001
Multivariate-adjusted RR (95% CI)	1.00	0.83 (0.71-0.97)	0.69 (0.58-0.82)	0.72 (0.61-0.86)	16.91	<.001

*For a definition of the Recommended Foods Score, see Table 1. For covariate-adjusted regression model inclusion criteria, see Table 2. CI indicates confidence interval.
†No. of subjects was 31 508 with 872 known deaths.
‡No. of subjects was 41 740 with 1551 known deaths.
§No. of subjects was 41 385 with 1196 known deaths.

Table 5. Age-Adjusted and Multivariate-Adjusted Relative Risk (RR) Estimates of Cause-Specific Mortality by Quartiles of Recommended Foods Score*

	Recommended Foods Score, Median (Range)				For Trend	
Variables	Quartile 1 7.0 (0-8)	Quartile 2 10.0 (9-11)	Quartile 3 12.0 (12-13)	Quartile 4 15.0 (14-23)	χ^2_1	*P* Value
All Sites Cancer†						
No. of deaths	228	255	175	185		
Age-adjusted RR (95% CI)	1.00	0.80 (0.67-0.96)	0.71 (0.58-0.86)	0.54 (0.45-0.66)	39.41	<.001
Multivariate RR (95% CI)	1.00	0.82 (0.68-0.98)	0.75 (0.62-0.92)	0.60 (0.49-0.74)	23.47	<.001
Coronary heart disease‡						
No. of deaths	76	80	52	66		
Age-adjusted RR (95% CI)	1.00	0.74 (0.54-1.00)	0.62 (0.43-0.88)	0.56 (0.40-0.78)	12.38	<.001
Multivariate-adjusted RR (95% CI)	1.00	0.75 (0.55-1.04)	0.70 (0.49-1.00)	0.67 (0.47-0.95)	4.84	.03
Stroke§						
No. of deaths	39	41	21	29		
Age-adjusted RR (95% CI)	1.00	0.73 (0.47-1.13)	0.49 (0.29-0.83)	0.48 (0.30-0.77)	10.75	.001
Multivariate-adjusted RR (95% CI)	1.00	0.76 (0.48-1.18)	0.54 (0.32-0.93)	0.58 (0.35-0.96)	5.50	.02
All other causes						
No. of deaths	157	185	101	152		
Age-adjusted RR (95% CI)	1.00	0.83 (0.67-1.03)	0.58 (0.45-0.75)	0.63 (0.50-0.78)	21.76	<.001
Multivariate-adjusted RR (95% CI)	1.00	0.92 (0.74-1.15)	0.71 (0.55-0.92)	0.83 (0.65-1.04)	4.29	.04

*For a definition of Recommended Foods Score see Table 1. For covariate regression model inclusion criteria, see Table 2. Cases with unknown cause of death (n = 223) were excluded for cause-specific analysis. Total of subjects included in analyses was 42 031. CI indicates confidence interval.
†Cancer defined by *International Classification of Diseases, Ninth Revision (ICD-9)* codes 140-208, except code 173.
‡Coronary heart disease defined by *ICD-9* codes 410 through 414.
§Stroke defined by *ICD-9* codes 430 through 438.

compared with those who consume 5 had a 40% higher risk of mortality. Huijbregts et al[22] have reported a 13% decrease in risk of mortality in men with healthy diet patterns. McCullough et al[23] recently noted a weak association between health outcome and a complex index of diet quality comprising both nutrient (mostly dietary fat related) and food group serving recommendations in men. The measures of diet quality mentioned above,[19-23] however, are not directly comparable with the RFS, which assesses diet quality relative to current food-based dietary recommendations. The only study reflecting a comparable approach to diet quality is the clinical trial of the effect of dietary patterns on blood pressure (Dietary Approaches to Stop Hypertension, the DASH trial).[24] In that study, a diet of fruits, vegetables, low-fat dairy, whole grains, and lean meat and poultry for 8 weeks reduced blood pressure in both hypertensive and normotensive subjects.

Conceptions of diet quality have evolved over time. Early in this century, nutrition scientists focused on preventing nutrient deficiencies; diets that provided the recommended intake levels of known essential nutrients and energy were considered desirable.[4] With increasing recognition of the role of diet in prevention and promotion of chronic diseases, dietary characteristics associated with decreased risk of chronic diseases have been promoted.[1-3] Therefore, recent US dietary guidelines reflect current beliefs about how nutrients, such as excess fat or foods such as fruits and vegetables, relate to risk reduction.[1-3] The diet quality measure used in this study is based on this recent guideline.

The RFS is a relatively simple measure of the extent of healthful eating and is portion-size independent. As is evident from Table 2, those with a high RFS had higher intake of energy and micronutrients but a lower percentage fat energy than those with a low score. It is unlikely that higher energy intake associated with RFS explains all the nutrient differences noted among the RSF quartiles. For example, the mean energy intake in quartile 4 was 131% of the mean level in quartile 1; however, mean levels of dietary fiber, vitamin C, folate, and provitamin A carotenoids in quartile 4 were 200%, 230%, 181%, and 253%, respectively, of mean levels in quartile 1. This suggests qualitative differences in food selection in association with higher RFS scores. Diets characterized by a low consumption of recommended foods may have marginal intakes of several nutrients (or other biologically active nonnutrient chemicals). Long-term marginal intakes of known essential nutrients or poorly understood nonnutrients may not be compatible with favorable health outcome. It is likely that the RFS-mortality association reflects a complex interaction of multiple dietary constituents beyond the biological activity of single nutrients.

The source of dietary information in our study was a single measure of usual dietary intake derived from a 62-item food frequency questionnaire. Although the food frequency questionnaire used in this study has been previously validated,[9-11] all measurement errors inherent in this retrospective method of dietary assessment are applicable to this instrument.[13,14] The problems of dietary measurement error and underreporting of food intake in dietary surveys have received considerable attention in recent years.[13,25-27] The extent to which the general dietary measurement error problem affects an aggregate dietary-pattern–based score like the RFS is unknown and merits further research. In this study, the RFS is computed by counting selected questionnaire items that are mentioned as having been consumed at least weekly independently of portion size reported; therefore, the RFS is relatively unaffected by misreporting of portion size. Use of the RFS may have allowed us to classify women, with reasonable accuracy, into broad categories of low- or high-risk dietary behaviors.

Our analyses largely exclude the possibility that reverse causation (due to women with preclinical disease at baseline reporting poor diets) accounts for the results observed. Deaths occurring early in follow-up (first 2 and 3 years) were excluded without materially affecting the results observed. Similarly, the trends observed remained significant after exclusion of women who reported chronic conditions at baseline.

It would be premature to conclude that the observed inverse relationship between RFS and mortality is causal. Given the observational epidemiologic nature of our study, the possibility that RFS is a surrogate for some unknown, poorly measured, or inadequately controlled determinant of mortality cannot be ruled out. Smoking status, physical inactivity, alcohol use, vitamin supplement use, and education level (a potential proxy for certain environmental exposures or lifestyle characteristics) were all associated with RFS in this study. Although we controlled for these and other factors as best as we could, we cannot dismiss the possibility of residual confounding. Furthermore, given that our cohort consists of participants in a screening study, it is possible our results have limited generalizability. It would certainly be valuable to see whether the RFS-mortality association holds in other large cohorts of men and women.

Although the strategy of examining global measures of diet quality is consistent with the complexity of diets consumed by free-living individuals, one limitation of this approach is that it makes it difficult to elucidate mechanisms through which the diet effect on a particular health outcome is mediated. From a public health perspective, however, it is not essential to wait for elucidation of every mechanism underlying health promoting activities and interventions. The results of the cause-specific analyses confirm the importance of dietary and nutritional factors for decreasing the risk of mortality from leading causes of death (all sites cancer, coronary heart disease, and stroke). The relatively weak association of RFS with all other causes of mortality (Table 5) may reflect the nonspecific nature of this category that includes causes unlikely to be related to diet.

The results from this large cohort of women with prospective follow-up suggest that dietary patterns characterized by consumption of fruits, vegetables, whole grains, low-fat dairy, and lean meat are associated with lower risk of mortality. Given the simplicity of the diet quality score used in this study, increasing the intake of recommended foods—without undue emphasis on learning about hidden fat, total amount and type of fiber, or individual vitamins and minerals—may represent a practical recommendation for improving health. Whether the observed protection is explicitly conferred by pattern of intake of recommended foods or reflects certain unknown factors related to both RFS and mortality remains an open question.

Funding/Support: There was no external funding for this study. Resources were available from Queens College and City University of New York, and the National Cancer Institute, National Institutes of Health.
Acknowledgment: We thank Lisa Licitra Kahle, Information Management Services, Silver Spring, Md, for computing assistance.

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